

Natural Selections



Department of Defense Natural Resources Program

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SPOTLIGHT: CAMP LEJEUNE GROWS AS A RESILIENT COMMUNITY

By Martin Korenek, Marine Corps Base (MCB) Camp Lejeune

The start of the Atlantic hurricane season, which runs from June through November, marks an unpredictable time for communities on the east coast of the United States. The scale of hurricane damage is often measured in the millions of dollars required for repair and replacement costs for infrastructure that includes homes, businesses, highways, power, water, sewer utilities, historic buildings and structures, beach and shoreline erosion, and water dependent structures such as docks and piers. The now too frequent disruption of lives, services, and recovery costs has given rise to the term "coastal resilience." Coastal resilience means investing in the community's ability to recover after hazardous events such as hurricanes, coastal storms, and flooding – rather than simply reacting to impacts. Many coastal communities take great pride in their continued ability to come together and "bounce back" after a storm.



Damage at Onslow Beach from Hurricane Florence. Source: United States Marine Corps (USMC)

Coastal resilience is critical for MCB Camp Lejeune to maintain its amphibious mission readiness. Camp Lejeune is a 156,000-acre facility made up of various satellite camps, housing, training areas, and the New River Air Station. The installation is located in southeastern North Carolina along the New River tidal estuary, extending along Stones Bay and the Atlantic Ocean. This location between two deep-water ports allows for fast deployment and enables Camp Lejeune to host the largest concentration of marines and sailors in the world.

With 11 miles of barrier islands, much of Camp Lejeune is vulnerable to shoreline erosion and coastal flooding. Over the past 25 years, 14 hurricanes have torn through the installation, causing damage and directly impacting the base's shores and military operations. Despite these setbacks,



Camp Lejeune Hurricanes (1996-Today)

Bertha	July 12, 1996
Fran	September 6, 1996
Bonnie	August 27, 1998
Dennis	August 30, 1999
Floyd	September 16, 1999
Irene	October 18, 1999
Isabel	September 18, 2003
Ophelia	September 14-15, 2005
Irene	August 27, 2011
Sandy	October 26-30, 2012
Matthew	October 8, 2016
Florence	September 14-17, 2018
Dorian	September 5, 2019
Isaias	August 4, 2020

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MESSAGE FROM THE NR PROGRAM

By Ryan Orndorff, Program Director

Welcome to the Fall 2020 Edition of *Natural Selections*!

This issue of *Natural Selections* highlights efforts across the United States to help increase resilience of military installations. The past few decades have brought extreme temperatures and frequent, catastrophic events such as droughts, floods, hurricanes, tornadoes, and earthquakes. Preparing for events like these has grown increasingly important for military installations to minimize damage and mission impacts. From revising policies and guidance documents to building sustainable structures and approaches, DoD has taken large strides to become more resilient.

Supporting the health and stability of an ecosystem is a key component to building a sustainable and resilient environment. Natural resources provide a vast array of ecosystem services that help in the recovery from extreme weather events, pollution, and other disturbances. DoD is continuously working to invest in these natural resources through management and conservation efforts.

Many installations are strategically located in areas that provide unique training and readiness capabilities. However, these areas can also be environmentally sensitive and at higher risk for impacts from a changing climate, causing some installations to experience frequent and intense catastrophic events. For example, Camp Lejeune, located on the coast of North Carolina, often experiences tropical storms. Learn how the installation has been impacted and how it has responded to protect natural resources and strengthen installation resilience in our spotlight article, "Camp Lejeune Grows as a Resilient Community."

Installations in vulnerable regions are using modeling and other tools to predict impacts from sea-level rise and wildfires to better prepare, increase their resilience, and reduce wide-scale damage and impacts to infrastructure, natural resources, and mission readiness. Read about how sea-level rise models are informing installation planning to address flooding impacts on Roi-Namur Island in the Pacific Ocean in "The Impacts of a Changing Climate on DoD Coastal Facilities in the Tropical Pacific Ocean." Also addressing climate risks, the AFWFB is using Wild Land Support Modules in the western United States to help reduce wildfires and increase resilience on installations. Learn how these modules are helping to reduce hazardous fuels and update Integrated Natural Resources Management Plans (INRMPs) in "The Air Force Wildland Fire Branch."



Hurricane as seen from space. Source: Getty Images

Extreme weather can decimate populations of threatened, endangered, and at-risk species in an already stressed environment. Read about how U.S. Army Garrison Pohakuloa Training Area (PTA) is identifying and documenting threatened, endangered, and at-risk species to help guide management actions, protect rare biodiversity, and enhance ecosystem resilience in "The Army is Managing Species at-Risk on the Big Island, Hawaii." DoD Partners in Amphibian and Reptile Conservation (PARC) has been leading a similar effort for herpetofauna species on military lands by continuously updating their Herpetofauna Species Database. Learn about this effort and how DoD PARC is helping installations better identify and track herpetofauna species in "Resilience of Military Lands Using Herpetofaunal Inventories."

To improve resilience at installations across the United States, DoD has developed new regulations, policies, and guidelines to help address changing climatic conditions. A key example is the recently published *Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Considerations into INRMPs*. Read about how this guide is helping to shape installation INRMPs to address climate-related vulnerabilities in "Practicing Climate Adaptation and Enhancing Installation Resilience." Another recent report, from the Environmental Policy Innovation Center, encourages partnerships between the Military Services and environmental groups to meet the common goal of sustainability while fostering aspects of installation resilience. Learn how the recommendations in the report will benefit both DoD and its partners while also protecting natural resources and yielding more resilient ecosystems in "Opportunities to Promote Conservation through Military Readiness."

I hope you enjoy reading this issue of *Natural Selections* and learning more about how DoD's efforts are creating more resilient installations across the United States. I'm excited about these ongoing efforts as they ensure continued access to training and testing lands, preserve DoD's capabilities in mission critical areas across the United States, and support DoD's natural resources.

We will publish our next newsletter in Spring 2021 and will focus on the 30th anniversary of DoD Partners in Flight (PIF). Please contact NaturalSelections@bah.com if you have any good DoD stories to share or would like to contribute an article.

Camp Lejeune and the surrounding community have repeatedly demonstrated their resourcefulness at surviving and recovering more resiliently even after severe storms.

In 1996, Hurricanes Bertha and Fran started a period of frequent hurricane activity on or near Camp Lejeune, producing visible signs of destruction across the base that are evident today. For example, these storms flattened beachfront dunes, burying picturesque maritime forests in sand and leaving behind piles of tangled debris as the water receded. Overwash created a new shallow water inlet that cut off vehicle access to the southern end, and countless recreational structures were damaged beyond repair. Tropical storm-force winds destroyed hundreds of acres of forests on and surrounding the installation. Old growth longleaf pine trees, used as nest-cavities by federally endangered red-cockaded woodpeckers, snapped by the hundreds. Damaged forests led to southern pine beetle infestations, destroying more trees and habitat. Pine stands containing loblolly pine located along the immediate coast suffered the greatest impacts because loblolly pine is less tolerant to storm damage than longleaf pine.

In the early 2000s, Camp Lejeune implemented timber salvage operations and reforestation measures to create more resilient forests. Forest managers salvaged as much timber as possible and converted those loblolly stands to longleaf pine. Those young pine stands, approximately 20 years old now, are established and producing cones. In 2018, Hurricane Florence tested the resilience of the young trees and confirmed research studies showing that conversion from loblolly to longleaf pine in the coastal plain increases the stability of the forests and lowers the risk of catastrophic loss from future storms.

Similarly, natural resources managers on Camp Lejeune have observed and documented over time that wildlife communities show great strength and possess the ability to recover after storms. For example, Camp Lejeune was home to 44 active red-cockaded woodpecker clusters in 1996 when Hurricanes Bertha and Fran came ashore. Twelve years later in 2008, that number doubled to 88 woodpecker clusters. Then, in 2018, the year Hurricane Florence struck, the number of active red-cockaded woodpecker clusters reached 131. Strong winds from Florence caused damage to managed forests, including the loss of over 150 known red-cockaded woodpecker cavity trees. After the storm, biologists installed 40 new artificial cavities to provide suitable nesting for every red-cockaded woodpecker cluster. A year later, in 2019, the number of active red-cockaded woodpecker clusters on Camp Lejeune reached 133, meeting 77 percent of the installation's recovery goal of 173 active clusters. Today the red-cockaded woodpecker population on Camp Lejeune continues to grow despite frequent hurricanes.

Damage from Hurricanes Bertha and Fran also caused beach erosion that required the relocation of numerous, iconic recreational facilities. Storm surges resulting from the hurricanes destroyed the entire Second Reconnaissance Battalion complex, located on Onslow Beach, a barrier island near Camp Lejeune, that was used for military training. The unit was permanently displaced and moved to temporary facilities until the Marine Corps rebuilt a new permanent location much farther inland. Aside from relocating structures inland, the Marine Corps made other changes to infrastructure such as replacing asphalt shingles with metal roofs to better withstand hurricane-force winds.



Heavy shore erosion along Onslow Beach from Hurricane Florence.
Source: USMC

Onslow Beach is also a popular place for recreation and a nesting beach for loggerhead sea turtles. In fact, the Marine Corps has monitored sea turtle nests there since 1979 and identified 21 sea turtle nests on the beach during the 2018 nesting season after Hurricane Florence damaged the area. While this number was well below the long-term average of 43.5 nests, it was consistent with low overall nesting numbers in North Carolina for 2018. Hurricane Florence arrived after most sea turtles had already nested, and many made it through their whole incubation period and hatched out before the storm. Ultimately, only four sea turtle nests on Onslow Beach were lost completely to Hurricane Florence, and the next summer was a remarkable one for loggerhead sea turtle nesting. The Marine Corps identified 92 sea turtle nests (91 loggerhead sea turtle nests, and one green sea turtle nest) on Onslow Beach during the 2019 nesting season, the highest number of sea turtle nests ever recorded there. The sea turtle has remained resilient despite damaging hurricanes and flooding that threaten populations through habitat loss and beach erosion.

The Camp Lejeune community came together after Hurricane Florence to clean up leftover debris and help restore public areas. Even though record-setting rainfall from the storm caused widespread damage, creating additional challenges and slowing recovery progress, life at the beach eventually approached normalcy. Marines have removed debris, resumed use of recreational facilities, rebuilt and planted dunes with native beach grasses including sea oats, and helped native vegetation make a remarkable recovery. The areas of the beach used by shorebirds, nesting sea turtles, and other wildlife have largely recovered as visible signs of the storm continue to fade.

Hurricanes and other significant storm events have become a fact of life for Camp Lejeune and most of North Carolina. Due to anticipated changes in climate, the threat of hurricanes with damaging winds and floods is expected to continue in the area. With a focus on the future, Camp Lejeune will continue to build a more resilient installation through planning, infrastructure, and resource management.

THE AFWFB

By Michelle Steinman, Air Force Civil Engineer Center Environmental Directorate, Wildland Fire Branch

Wildfire risk has dramatically increased, particularly in the western United States, as a result of changing climatic conditions. Warmer temperature trends, along with increased periods of drought, are exacerbating large and intense wildfire outbreaks. Unplanned wildfires on installations not only lead to devastating impacts to infrastructure and natural resources, but also threaten the military mission. DoD focuses on wildfire management as an important component of installation planning and resilience. In particular, the Air Force is at the forefront of creating a structured process that effectively coordinates with stakeholders to successfully mitigate and manage wildfires.

The Air Force established the AFWFB under Civil Engineering Transformation to specialize in managing wildland fire threats. Since 2012, the AFWFB has grown into an inter-agency network of nationally qualified wildland firefighters. The group is focused on enabling mission readiness by maintaining ecosystem integrity and mitigating wildfire risk at Air Force installations. AFWFB has over 80 staff members, including wildland fire experts from the Air Force, the U.S. Fish and Wildlife Service (USFWS), Colorado State University, the Bureau of Land Management (BLM), the Forest Stewards Guild, and the University of Montana. Headquartered at Joint Base San Antonio, Texas, the AFWFB's responsibilities include developing policy and guidance; leveraging partnerships with land management agencies; issuing and certifying National Wildfire Coordinating Group qualifications; collecting and analyzing wildland fire data, and vehicle and equipment authorizations; and developing wildland fire management plans.

Field support is a key component of the AFWFB's strategy with 14 strategically placed Wildland Support Modules (WSMs). WSMs are made of up to 12 wildland fire experts with a suite of vehicles and equipment. The WSMs focus on executing hazardous fuel reduction projects that support each installation's

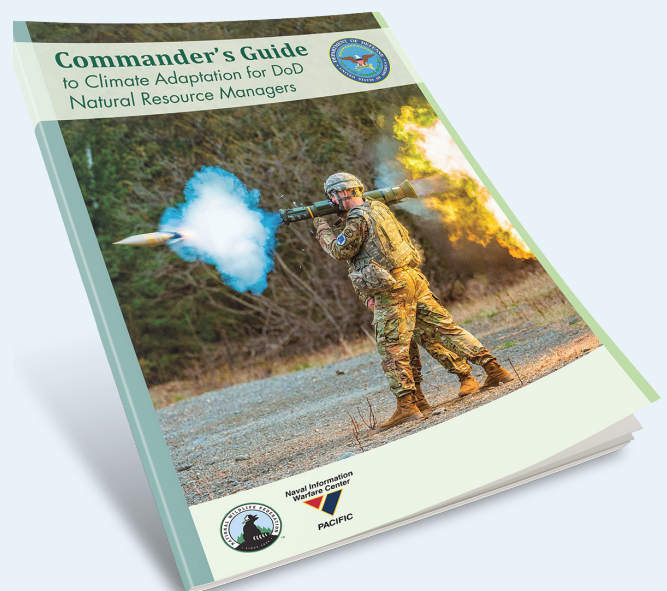
unique INRMP and Wildland Fire Management Plan, thus increasing the installations' resilience to wildland fire. The WSMs have facilitated better working relationships between natural resources managers and fire and emergency service (FES) personnel who have collectively reduced hazardous fuels on over 130,000 acres through prescribed burns and brush removal each year. As a qualified and capable resource, the WSMs supplement FES and mutual aid wildfire response to more than 100 wildfires annually.

The inter-agency makeup of the AFWFB allows for sharing resources and improving competencies across all agencies. Personnel gain critical on-the-ground experience with fire behavior across a variety of fuel types and weather conditions. Prescribed burns are one example of important inter-agency collaboration to prevent wildland fires. Prescribed burns reduce the amount of excessive vegetation on the forest floor, encourage the growth of native vegetation while killing off invasive species, and maintain plant and animal species habitats that depend on periodic fires. Recently, the Ellsworth AFB WSM, including the installation's natural resources and FES personnel, partnered with the National Park Service (NPS) and Box Elder Volunteer Fire Department to complete a 273-acre prescribed burn on the installation. The burn improved management of natural habitats and rangeland conditions, while reducing the hazardous fuel load. Prescribed burns also increase an installation's resilience through reducing the risk of a wildland fire outbreak. Ellsworth WSM and FES also assisted the NPS and USFWS with a 260-acre prescribed burn at Mount Rushmore National Memorial.

AFWFB will continue leading efforts to minimize wildfire risk, reduce hazardous fuel at Air Force installations, and identify new opportunities for collaboration. The Branch is well positioned to develop wildland fire management guidance in response to changing environmental conditions. This guidance is important to maintaining healthy landscapes and mission readiness. Predicting and preventing wildfires supports resilience across the Department as installations work to avoid damage to critical infrastructure and equipment, as well as reduce mission impacts.

COMMANDER'S GUIDE TO CLIMATE ADAPTATION FOR DOD NATURAL RESOURCE MANAGERS

Over the coming decades, DoD installations will experience significant risks from climate related changes in the environment, which could compromise the capacity of these lands and waters to support military readiness activities. To address these risks, the DoD Legacy Program provided funding to the National Wildlife Federation to develop the *Commander's Guide to Climate Adaptation for DoD Natural Resource Managers*. This Commander's Guide provides DoD leadership an overview of the *Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Considerations into Integrated Natural Resource Management Plans* that was released in June 2019. Learn more about the full guide on page 7 in the article, "Practicing Climate Adaptation and Enhancing Installation Resilience." The Commander's Guide is designed to help military leadership better understand how climate impacts to DoD natural resources can pose risks to training and testing capabilities, and how installations and their natural resource managers can plan for these risks to enhance installation resilience and sustain military readiness. Check out the new Commander's Guide today!



THE IMPACTS OF A CHANGING CLIMATE TO DOD COASTAL FACILITIES IN THE TROPICAL PACIFIC OCEAN

By Dr. Curt D. Storlazzi, U.S. Geological Survey (USGS)

The USGS, the National Oceanic and Atmospheric Administration (NOAA), Deltares, and the University of Hawaii (UH) recently completed a study investigating the impact of a changing climate and sea-level rise on Roi-Namur Island on Kwajalein Atoll in the Republic of the Marshall Islands, which is part of the Ronald Reagan Ballistic Missile Defense Test Site (RTS). The isolated location of RTS makes it uniquely suited to support realistic testing of missiles and intercept scenarios with minimal safety and environmental concerns. In addition, this unique location supports research and development for space and missile programs and space reconnaissance and surveillance operations. RTS has been a critical component of the Pacific Range, with the world's most advanced telemetry, optics, and radar instrumentation used to collect metric and signature data on missiles.



Ronald Reagan Ballistic Missile Defense Test Site. Source: Massachusetts Institute of Technology Lincoln Laboratory



Map of Kwajalein Atoll. Source: Bev Schilling, Stars and Stripes

REBUILDING OFFUTT AFB AFTER FLOODS

Located about 10 miles south of Omaha, Nebraska, and less than two miles west of the Missouri River, Offutt AFB is the headquarters of the U.S. Strategic Command, the 557th Weather Wing, and the 55th Wing of the Air Combat Command. The mission of the U.S. Strategic Command is to deter strategic attacks and use forces to guarantee security of the United States and allies. The 557th Weather Wing is the lead military meteorology center, responsible for delivering situational environmental awareness to DoD entities around the world. The 55th Wing and Air Combat Command mission is to provide intelligence, surveillance and reconnaissance, and nuclear command and control to national leadership and warfighters always.



During the wettest period on record for the United States between January and May 2019, the Missouri River flooded Offutt AFB. Leading up to the flooding, the midwestern United States experienced several severe weather outbreaks, causing major flooding along the Missouri River. In addition, this region experienced below average temperatures through early March, ending with a blizzard. Following the blizzard, temperatures quickly rose again causing rapid snowmelt. The ground, still frozen from winter, provided little absorption causing high runoff volumes to local waterways.

When floodwaters from the Missouri River breached the levee system and began spilling over into Offutt AFB on March 15, 2019, personnel quickly scrambled to put in place 235,000 sandbags and 460 flood barriers to minimize damage. Despite these efforts, the floodwaters soon damaged 130 structures on base, of which 60 could not be repaired. These buildings included the headquarters facilities of the 55th Wing, 55th Security Forces Squadron, 97th Intelligence Squadron, and 343rd Reconnaissance Squadron and the Bennie L. Davis Maintenance Facility. In some areas of the base, floodwaters were as deep as nine feet. While airmen and women began repairing Offutt AFB, flight operations and support staff were temporarily relocated to Lincoln Air National Guard Base. In addition, the Air Force relocated several reconstructed buildings to areas at higher elevation on base.

Today, the Air Force is focused on ensuring that the rebuild of Offutt AFB considers resilient methodologies to better withstand extreme flooding events in the future. The Air Force has estimated that it would cost \$420 million to repair and rebuild the base's damaged areas. As temperatures continue to fluctuate between extremes and heavy precipitation events become more common, the area is expected to see more record and extreme flooding. The need to build Offutt AFB as a more resilient installation will increase to avoid damage and training impacts from future flood events.

The primary goal of this study was to determine how a changing climate and sea-level rise influence wave-driven flooding and the resulting impacts to infrastructure and freshwater resources on atoll islands. DoD used three widely accepted climate and sea-level rise scenarios to determine the influence of these factors. Of the three scenarios, the best case assumes reduced greenhouse gas emissions by mid-21st century; “business as usual” assumes continued growth in carbon emissions; and the worst-case scenario assumes ice sheet collapse. These scenarios are based on [regional sea levels for coastal risk management](#). Understanding the timeframe of these impacts is critical for DoD to create mitigation plans and identify the measures needed to continue military training at this site.

Data and information from this research will support the Department’s efforts to minimize flooding in the region and weather-related threats to the mission. For example, when mean sea level increases by 0.4 meters, the combination of sea-level rise and wave-driven coastal flooding will begin to have significant negative impacts on Roi-Namur. Without active management, the annual amount of seawater flooded onto the island during storms will make the groundwater non-potable year-round. This research identified that the “tipping point” for groundwater, or the time at which potable groundwater on Roi-Namur will be unavailable, is projected to occur sometime between 2035 and 2065, if the military does not use mitigation measures such as desalination or an outside freshwater supply. Without an available freshwater supply, species on the island would be impacted and the coast would become more susceptible to erosion.

In addition to impacting the freshwater supply, sea-level rise and wave-driven flooding will disrupt regular operations on Roi-Namur including base housing, the dining hall, and several maintenance facilities. When mean sea level rises 1.0 meter over current conditions, at least half of the island is projected to flood annually. This “tipping point” in island flooding – the time at which the majority of Roi-Namur’s land would be flooded annually – is projected to occur between 2055 and 2065 for the worst-case climate scenario, between 2060 and 2070 for the “business as usual” climate scenario, and sometime after 2105 for the best-case scenario. Flooding from seawater is expected to have detrimental impacts to infrastructure, shorelines, roads, runways, and other recreational areas on and surrounding the installation. RTS also houses critical radar and sensors that

DOD NR PROGRAM STORYMAP UNDER DEVELOPMENT

The NR Program is developing a storymap, which uses custom maps, photographs, and other visual elements to tell a story. This storymap will describe the NR Program and highlight various success stories across a range of themes including biodiversity, ecosystem management, planning tools, and public access and recreation. If you or any of your colleagues have new or prominent successes on topics such as threatened and endangered species, invasive species, wildland fire, installation resilience, or outdoor recreation, please submit them to us at DoDNatRes@bah.com. We want to feature the best and most significant successes from as many Military Services and Defense Agencies as possible, so send us your stories with any associated pictures or videos today!



Waves wash over a road on Roi-Namur Island, Kwajalein Atoll, Republic of the Marshall Islands. Source: Peter Swarzenski

support mission readiness and military training. Relocating the critical radar and sensors would impact the military mission. Many of the adjacent islands on Kwajalein Atoll that are inhabited and/or have DoD facilities will experience similar impacts. This region has proven to be a vital strategic asset to DoD and other national space operations given its remote location in the Pacific as well as the advanced technology this base supports.

Some recommended mitigation measures to reduce these impacts include building a taller coastal berm to reduce flooding, or building an impermeable subsurface wall below the levee to block seawater from entering the aquifer and keeping inland freshwater from discharging into the sea. Other mitigation measures consist of pumping surplus freshwater on top of the intruded saltwater to force saltwater out and allow the aquifer to recharge more quickly after flooding events, or pumping out intruded saltwater from flooding events to allow the aquifer to recharge more quickly by natural rainfall.

These findings for sea-level rise and wave-driven flooding are also highly relevant to other tropical, reef-lined islands. The majority of housing and critical infrastructure (e.g., ports, roads, airports, hospitals, power plants, water treatment plants) on high tropical islands, such as Hawaii, Guam, the Commonwealth of the Northern Mariana Islands, American Samoa, Puerto Rico, and the U.S. Virgin Islands, is located within a few meters of current sea level. Scientists predict these islands will experience similar threats from sea-level rise and wave-driven flooding to those described in the results for atoll islands. These models help land managers understand coastal hazards on Pacific atolls and other reef-lined islands. Being able to predict changes allows managers to shape strategies and develop plans to protect infrastructure and natural resources in the future. Understanding the impacts of sea-level rise and wave-driven flooding will help DoD better prepare installations to minimize impacts to the military mission or prevent damage to critical infrastructure. Better preparedness and adaptation are now primary components of management strategies to maintain military training activities in these vulnerable regions.

For more information, download the full report, titled “The Impact of Sea-Level Rise and Climate Change on Department of Defense Installations on Atolls in the Pacific Ocean (RC-2334),” or visit the [USGS](#) website.

PRACTICING CLIMATE ADAPTATION AND ENHANCING INSTALLATION RESILIENCE

By Dr. Bruce A. Stein, National Wildlife Federation

DoD lands and waters harbor an extraordinary array of wild species and natural ecosystems, essential for a high-quality training and testing environment. Understanding climate-related vulnerabilities to these natural resources, and designing strategies to reduce resulting risks, is critical to maintaining mission requirements and supporting installation resilience. Just over a year ago, the DoD released *Climate Adaptation for DoD Natural Resource Managers*, a guide designed to help installations incorporate climate concerns into INRMPs. The guide is a tool for implementing policy in *DoD Manual 4715.03, Integrated Natural Resources Management Plan Implementation Manual*, which calls for installations to address potential climate impacts when revising or updating their INRMPs.



To reduce climatic risks, adaptation will often require proactive management, including expanded use of prescribed burns (Joint Base Lewis-McChord). Source: Scott Hansen

The guide introduces the emerging discipline of climate adaptation, reviews the impacts a changing climate may have on various INRMP program elements, and provides options for incorporating climate considerations within the structure of the INRMP document itself. The guide also offers a structured planning process for evaluating climate-related risks and drafting strategies and actions to address impacts that could compromise installation functions and readiness.

Natural resources personnel can use the guide at several levels, depending on where an installation is in both their INRMP planning cycle and their efforts to address climate concerns. The guide outlines the basic process for adaptation planning, including climate vulnerability assessments and design of strategies to reduce associated risks. The guide lays out a six-step INRMP adaptation planning framework designed to help installation managers understand how a changing climate may affect their resources and management objectives; develop and document potential adaptation responses; and ultimately evaluate, select, and implement climate-informed natural resources projects.

This step-by-step cycle is supported by a series of detailed worksheets that can help managers systematically work through the adaptation process. By providing ways to elicit and record key information and decisions, the worksheets also offer tools for revisiting and updating adaptation planning over time – the essence of “iterative risk management.” Importantly, the six-step planning framework and associated worksheets are intended as an aid, not a mandate.

The adaptation guide offers different options for how installations can incorporate climate considerations into the INRMP process and document.

- For those just beginning to think about climate impacts on their installation, the guide provides an overview of climate science, an introduction to adaptation and resilience principles, and a selection of relevant literature and other informational resources.
- Those undertaking a complete INRMP revision can address a changing climate throughout the INRMP using a “full-integration” approach. This approach helps to ensure that climate concerns are integrated across the full range of resources and program activities.
- For those just starting to consider climatic concerns, or who are between full revision cycles, can address a changing climate in an INRMP appendix using an “appendix-only” approach.

The guide and its [associated resources](#) (i.e., worksheets, fact sheets) are already helping to inform adaptation planning and INRMP revisions at installations nationwide. In one example, managers at the Army’s PTA on the Big Island of Hawaii have drawn on the guidance to help craft an approach for integrating climate considerations into the INRMP for this biologically diverse installation. Pohakuloa is home to large tracts of sub-alpine and dryland tropical ecosystems, with the latter being one of the rarest habitats in the world. To align with the overall INRMP update cycle, the team is using an “appendix-only” approach, and plans to more fully integrate climate throughout the INRMP during the next formal revision.

The guide is also helping managers in Alaska, a state experiencing particularly rapid warming and unique climate-related threats like melting permafrost, as they update an Air Force INRMP addressing multiple installations, including some particularly vulnerable coastal sites. In New Hampshire, Army National Guard managers are using the guide’s INRMP adaptation planning framework to explore the changing climate’s effects and potential solutions.

Climatic changes are expected to amplify existing threats to DoD installations’ unique ecosystems and numerous rare species. Enhancing the resilience of threatened and endangered species to climatic and other threats on installations is an important focus of installation planning, consistent with USFWS biological opinions. Active management to improve the resilience of these species includes invasive plant control, wildland fire management, predator removal, and genetic conservation actions for rare plants.

Installations across the country face varying climate concerns and management challenges, and no one-size-fits-all approach exists for climate adaptation. However, by helping managers understand the principles and processes underlying effective adaptation planning, the DoD climate adaptation guide serves as an important tool for enhancing installation resilience and maintaining military readiness.

RESILIENCE OF MILITARY LANDS USING HERPETOFAUNAL INVENTORIES

By Robert E. Lovich and Chris E. Petersen, DoD PARC

Herpetofauna (i.e., amphibians and reptiles) are excellent indicators of ecosystem health and resilience. Aside from marine reptiles (e.g., sea turtles and sea snakes), which have massive ranges spanning the globe's non-polar waters, most herpetofauna have low vagility, or mobility, and have small home ranges. Herpetofauna tend to be small-bodied, and most have specialized life histories closely tied to the ecosystem they inhabit. A reduction of amphibian and reptile species in an area may indicate that ecosystem health is declining and the land's ability to recover is impaired.



Marbled Salamanders (*Ambystoma opacum*). Source: Kenneth Erwin

DoD has achieved tremendous success creating resilient habitats on military lands for the herpetofauna species reliant upon the land. Military landscapes maintain high levels of biodiversity compared to other federally owned lands in the United States (Stein et al. 2008, Aycrigg et al. 2015), and studies have documented notably high amphibian and reptile diversity on DoD lands (Petersen et al., 2018). Biodiversity not only provides a natural resource benefit for the species inhabiting DoD lands, but is also key to ensuring DoD full access to training and testing areas.

DoD PARC relies on species surveys and inventories to proactively manage natural resources and minimize any potential impacts to sensitive and other herpetofauna species on installations. In addition, over the past decade, the DoD PARC network has tracked Sikes Act and INRMP implementation, policy changes, and regulations (e.g., Endangered Species Act (ESA), state protections) that could impact these species and the training and testing mission. With this information, DoD PARC has built considerable knowledge and evidence supporting of the link between resilience of military lands and healthy herpetofauna.

DoD PARC's biggest contribution to understanding herpetofauna biodiversity and military land resilience is the Herpetofauna Species Database on military lands. In 2013, the DoD PARC team took on the enormous task of developing the first ever agency-wide inventory of amphibians and reptiles on DoD lands. This effort included a review of over 415 installations and culminated in the [DoD PARC Amphibian and Reptile](#)

SMART IRRIGATION PRACTICES FOR A SUSTAINABLE FUTURE

Water security is critical to installation readiness and resilience as it supports training and testing activities, operations, and maintenance. However, many DoD installations, especially in the western United States, are experiencing water shortages, creating a need for them to think through water conservation and find smart alternatives to ensure adequate water supplies. For example, some installations are switching to high-efficiency irrigation systems that use sensors and forecasting to maximize water efficiency. Several installations located in the southwestern United States have also found creative ways to repurpose wastewater for irrigation. Maintaining water resources is a fundamental strategy in increasing installation resilience.

One of the many ways DoD is improving water conservation is by using native and drought-resistant plants that require very little maintenance and irrigation beyond establishing and efficiently arranging them to maximize water savings. This practice is formally known as "xeriscaping," or dry landscaping. Denver Water coined the term after Denver, Colorado, experienced a difficult drought period in the late 1970s and early 1980s. There are seven essentials for xeriscaping: planning and design, soil improvement, plant selection, practical turf areas, efficient irrigation, mulch, and maintenance.



An elaborate, yet water-saving xeriscape design has been installed at the Navy Exchange Mall and Commissary at Pearl Harbor, Hawaii. Source: Thomas Obungen

Today, xeriscaping is increasingly helping installations in the western United States conserve water. At Naval Base (NAVBASE) San Diego, California, and Naval Air Station Fallon, Nevada, the innovative use of artificial turf and rock or mulch groundcover has significantly decreased irrigation needs. Similarly, the USMC has converted landscapes, replacing water-thirsty plants with drought-resistant native species, at seven installations on the west coast, effectively reducing water use. Nellis AFB implemented a similar practice in the Mojave Desert, which receives an average of just 3.5 inches of rain per year. Through this effort, Nellis AFB has reduced water consumption by 10 percent, making the installation more resilient especially in the event of a future drought.

More than half of the United States is predicted to experience water shortages in the near future. Investing in conservation through best management practices such as xeriscaping is a key component to increasing installation resilience.

[Biodiversity Report](#) and a peer-reviewed publication (Petersen et al 2018). As a result, DoD PARC now has confirmed 440 herpetofauna species on DoD properties and an additional 86 species potentially present. This inventory is continuously updated and confirms that military lands contain significant herpetological biodiversity. Specifically, 66 percent of all native herpetofauna species in the continental United States are confirmed present on DoD lands. In addition, several DoD installations have higher biodiversity rates than the surrounding regions. For example, Camp Pendleton in California, containing plenty of natural habitat, has the highest herpetofauna biodiversity in San Diego County. The report indicates that military installations have crucial capabilities and resilience in maintaining herpetofaunal biodiversity despite changing climatic conditions and external threats such as encroachment.

At the local level, DoD PARC is involved with in-house efforts to inventory and monitor herpetofauna on military installations and document changes in the herpetofauna biodiversity over time.

During 2018 and 2019, DoD PARC conducted surveys for the presence of amphibians and reptiles on MCB Quantico. The objective of the survey was to develop an updated inventory of herpetofauna species present on the base to compare with surveys conducted over 30 years ago by Dr. Joseph Mitchell. DoD PARC's survey confirmed the presence of the species recorded by



Rob Lovich conducting surveys at MCB Quantico. Source: DoD PARC

Dr. Mitchell while finding five new species. This data suggests that MCB Quantico's management actions have helped maintain healthy, resilient habitats for both military training and herpetofauna. These studies allow DoD to measure the success of its management practices while determining which practices may be replicated at other installations with similar species and habitats.

DoD PARC has recently held its annual meetings at installations that could benefit from an updated herpetofauna survey. For example, following the 2018 annual meeting at Fort Indiantown Gap, Pennsylvania, the DoD PARC team, with help from installation personnel, conducted a rapid herpetofauna survey that documented 24 species in a single day. Several of the species detected are considered at-risk species. Sadly, all snakes sampled tested positive for Snake Fungal Disease (SFD), but this finding was an important data point for what would become a nationwide SFD study on DoD installations (Allender et al. 2019).

Last year, DoD PARC held its annual meeting at Camp Minden, Louisiana, an installation with few species of herpetofauna recorded in its INRMP. In addition to the meeting, the



Eastern Hognose Snake (*Heterodon platirhinos*) with SFD. Source: Paul Block

DoD PARC team trained installation staff on surveying for herpetofauna and facilitated two days of field surveys. By the end of the survey, the team detected 25 species. This is approximately a 25 percent increase in species that had previously been documented in the installation's INRMP. This survey was a great resource for Camp Minden's next INRMP update, confirming they have a robust number of species on their installation to report and meet the requirements of the Sikes Act. Using this information, they can tailor their INRMP to include management and conservation goals for these species. It also resulted in three new Parish records for the prairie kingsnake, western milksnake, and broad-headed skink.



Prairie Kingsnake (*Lampropeltis calligaster calligaster*) found at Camp Minden. Source: Chris Petersen

One of the clearest examples of herpetofauna biodiversity and DoD resilience is highlighted in the report *Biodiversity of Amphibians and Reptiles at the Camp Cady Wildlife Area, Mojave Desert, California and Comparisons with Other Desert Locations* (Cummings et al., 2018). DoD, USGS, and other partners analyzed the herpetofauna at Camp Cady Wildlife Area in the Mojave Desert of California. This large-scale effort used the DoD PARC Herpetofauna Species Database to compare species inventories from six military installations in the Mojave and Sonoran Desert ecoregions of California. All six installations had much higher numbers of herpetofauna species than the Camp Cady Wildlife Area, and some rivaled the total number of herpetofauna species found in the entire Mojave Desert. These remarkable findings show the value of the Herpetofauna Species Database and underscore the healthy, resilient ecosystems and high overall herpetofauna diversity on vast areas of southwestern military installations.

In summary, DoD lands exhibit remarkable numbers and diversity of herpetofauna, and this diversity contributes to the resilience of military lands. DoD PARC strives to document and monitor amphibians and reptiles on military lands by conducting surveys and keeping its database current. Using species diversity as a measuring stick, comparisons of new survey datasets with older ones can provide insights into overall ecosystem health and the resilience of military lands.

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PROTECTING INSTALLATION RESOURCES AT FORT HUACHUCA THROUGH THE REPI CHALLENGE

Adapted from the 2018 REPI Challenge Awards winner fact sheets

The REPI Program works across multiple federal, state, and local agencies to prevent encroachment on or near military lands. The goal is to preserve and protect military training, testing, and operations, thus increasing their overall resilience. Through the REPI Program, DoD establishes partnerships among the Office of the Secretary of Defense, Military Services, private conservation groups, and state and local governments. Partners share the cost of a conservation easement or land acquisition while preserving compatible land use and natural habitats near installations and ranges that support critical military capabilities. The REPI Program has completed 2,107 transactions to protect 688,258 acres of land across the United States.

Established in 2012, the REPI Challenge is an annual awards program dedicated to recognizing and funding projects that conserve land at a greater scale. These projects also test promising ways to finance land protection by harnessing the creativity of the private sector to access and leverage unconventional funding sources and market-based approaches. Many installations face challenges as a result of encroachment

and incompatible development. By preserving nearby compatible land through programs like the REPI Challenge, installations can protect their mission, reduce regulatory burdens, and improve resilience.

In 2018, one of the REPI Challenge award winners was a project, submitted by the Arizona Land and Water Trust, that benefited the Fort Huachuca Sentinel Landscape. Located in the Sonoran Desert, Fort Huachuca is home to the premier restricted military airspace for unmanned aircraft system training in the Western United States. In addition, Fort Huachuca supports training for U.S. Air Force, Marine Corps, and Border Patrol personnel.



Fort Huachuca Sentinel Landscape. Source: Arizona Land and Water Trust

Recently, urban sprawl and population growth have presented new challenges to the historically remote setting of the installation. These challenges threaten critical airspace, increase electromagnetic interference in the Buffalo Soldier Electronic Testing Range, and heighten competition for limited water resources. Through the REPI Challenge, the Fort Huachuca Sentinel Landscape partnership, including the Arizona Land and Water Trust and the U.S. Department of Agriculture's Natural Resources Conservation Service, is working to increase the installation's resilience by protecting the Fort Huachuca water supply and promoting compatible land use surrounding the installation.

Funding from the REPI Challenge is critical to increasing resilience at Fort Huachuca. A portion of the award will help establish a conservation easement on the Rose Tree Ranch. The easement is a 1,150-acre parcel located in the Babocomari River Watershed and the Sonoita Grassland Conservation Area. The Rose Tree Ranch is situated near the Coronado National Forest where several mountains and canyons are hotspots for biodiversity. For example, Mt. Graham, located in the Pinaleno Mountains, is the most diverse mountain range in North America, with 11 endemic species. This easement will permanently protect the natural habitat of the Rose Tree Ranch while also reducing competition for water resources in the San Pedro River Watershed by curtailing drilling of over 200 new wells for housing developments. Additionally, by preventing development of the Ranch, this project will ensure proper land and airspace conditions for military testing and training activities. Developing this area might otherwise force local species to relocate onto Fort Huachuca, which could restrict military training and testing.

The Arizona Land and Water Trust allocated the rest of the award to a Water Supply and Use Assessment on the Rose Tree Ranch, conducted by Alyward McCoy Polz Insights. The assessment is the product of a long-standing partnership between REPI and the Arizona Land and Water Trust to link conservation easements with innovative water conservation, transaction, replenishment, and restoration opportunities. Completed in Spring 2020, the assessment included an analysis of groundwater levels and surface flows, a survey of current irrigation and water use, and a comprehensive review of historic pumping records and water rights. The assessment provided several recommendations to address groundwater deficit in the Upper San Pedro Basin, which will enable local Sentinel Landscapes partners to take innovative action to strengthen water security for Fort Huachuca and the surrounding communities.

This project protected 1,150 acres with \$1.1 million in REPI funding and \$3.1 million in partner funding. Through a conservation easement placed on the Rose Tree Ranch, Fort Huachuca will avoid land use conflicts, prevent encroachment on critical air space, and avoid increased competition for water resources — all of which will enhance the installation's overall resilience. In addition to the benefits for the installation, this project preserves natural open space and the many unique species that rely on this area for survival. These outcomes are important in sustaining the long-term military training capabilities that take place at Fort Huachuca and boosting the installation's resilience to changing climatic conditions. REPI projects such as this contribute to the longevity of farms, forests, and rangelands while protecting the critical missions at DoD installations and ranges.

TAKING ON SOLAR ENERGY AVIAN CHALLENGES

By Diane Walsh, Marine Corps Air Station (MCAS) Camp Pendleton

Since Congress passed the American Recovery and Reinvestment Act of 2009, the rate of utility-scale solar energy development has increased rapidly on many military installations. Utility-scale solar facilities produce energy that is fed into a grid while also producing energy for a specific installation. Energy independence from oil provides resilience by allowing the military to execute their mission with little to no interruption in the event of a natural disaster or other supply chain interruption. The DoD supports clean energy by creating solar farms or leasing out portions of its land for commercial solar development to decrease energy costs. Solar energy provides the benefit of energy independence and security. Additionally, shifting to clean energy is a critical step in military installation resilience, especially as impacts from a changing climate create risks to the mission and readiness.



Individual panels within a utility-scale solar farm. Source: Argonne National Laboratory

Despite the many benefits utility-scale solar energy can offer, DoD is also learning more about some of the negative ecological and environmental impacts. For example, avian species and their habitats may be at risk from solar energy development. The nature and magnitude of avian-solar interactions are not well understood. Without understanding this interaction, DoD may experience impediments to solar energy development through delays in environmental reviews during the National Environmental Policy Act (NEPA) process and decision making, or increased costs of avian monitoring and mitigation activities.

To counter these impacts, in January 2016, DoD joined other federal and some state agencies to establish a multi-agency Avian-Solar Collaborative Working Group (CWG) to facilitate interagency communication and collaboration to advance the knowledge of avian-solar interactions. This working group consists of environmental organizations, academics, and solar companies. The primary goal of the CWG is to develop better information to inform future agency actions to reduce the impacts of solar energy development on birds. In 2016, the CWG released an [Avian-Solar Science Coordination Plan](#) that identified several priorities to improve the understanding of avian-solar interactions at utility-scale solar energy facilities.



Utility-scale solar farm and panels. Source: Argonne National Laboratory

These CWG priorities fall within three broad research themes:

- Collecting data on avian populations and their interactions with solar facilities to assist in understanding potential avian-solar impacts. This information will help DoD to make informed environmental decisions regarding siting, permitting, monitoring, and mitigation measures.
- Evaluating the mechanisms by which birds interact with solar facilities. Avian attraction and collision fatalities have occurred at all types of utility-scale solar facilities. Understanding how to minimize these interactions will help protect solar infrastructure, as well as reduce avian fatalities, especially to sensitive bird species.
- Collecting data to better understand the magnitude of functional impacts of utility-scale solar facilities on avian populations. These data will be useful in determining avian mortality at DoD solar facilities from natural and human causes.

The CWG is currently working with the Avian Knowledge Network (AKN) to use the existing AKN platform to share data between members of state and federal agencies, nongovernmental organizations, industry, and others. Federal agencies including DoD, BLM, Bureau of Ocean Energy Management, NPS, U.S. Forest Service, and USFWS partnered to create the Federal Avian Data Center (FADC), a portal into the AKN, with the purpose of improving avian data sharing and

decision support. The FADC enables contributions of data to the AKN to make the system's growing collection of bird information more accessible and useful for research and decision-making. This data provides partners with the ability to make important decisions on species health, population status and trends, specific stressors, and best management practices.

The U.S. Department of Energy (DOE) is currently conducting systematic bird mortality monitoring as part of the CWG efforts. DoD PIF, in partnership with the DOE, Office of Energy Efficiency and Renewable Energy, is participating in a project titled "Developing a Deep Learning-Computer Vision Framework to Monitor Avian Interactions with Solar Energy Facility Infrastructure." DoD PIF selected Luke AFB in Arizona to help DoD solar facilities monitor and avoid bird collisions with solar infrastructure. Luke AFB, as part of its Bird/Wildlife Aircraft Strike Hazard (BASH) program, actively manages open land immediately adjacent to the airfield to prevent BASH incidents. The data gathered from this project will provide not only a framework, analysis, and monitoring protocol for other DoD installations to assist in future DoD solar farm initiatives but will further aid in the site planning approval process while protecting important avian species. This monitoring serves as a tool to identify unusual or unexpected bird use of the solar array and to maintain safety for human and feathered aviators.



Solar array at Naval Air Station Crane. Source: DoD PIF

As the construction of solar farms on DoD lands continues to increase, the need for consistent monitoring and access to the data support and decision-making tools also grows. By providing access to avian monitoring and research data, the FADC will support mission resilience and readiness by helping to facilitate NEPA reviews and assessments of DoD training impacts on migratory birds in compliance with the Migratory Bird Treaty Act and the "Readiness" Rule. For DoD, using the FADC increases the value of all data collected and ensures the long-term sustainability of funds spent on avian projects by archiving and disseminating avian data across each Military Service. Through these initiatives, DoD creates a legacy of safety, energy resilience, independence, and security for the current and future sustainable military mission.

THE ARMY IS MANAGING SPECIES AT RISK ON THE BIG ISLAND, HAWAII

By Dave Jones and Lena Schnell, Center for Environmental Management of Military Lands, Colorado State University (CEMML/CSU)

Island ecosystems harbor many rare and endemic species that are vulnerable to invasion and new disturbances. U.S. Army Garrison, PTA personnel, located in one of the most biodiverse areas in the world, are persistently working to prevent additional species listings under the ESA. Currently, PTA manages 20 ESA-listed plants and six ESA-listed animals, as well as many additional species at-risk (SAR) to prevent future ESA listings.

Avoiding species listings can increase installation and mission resilience. Specific threats to listed species and SAR at PTA include habitat loss and degradation, predation by non-native animals (e.g., feral ungulates, rats, cats, mongoose), wildland fire, extreme weather events (e.g., drought), land development and military activities, and invasive species.

A changing climate will likely exacerbate invasive plant competition, wildland fire risk, and drought stress.



Cream cheesewood (*Pittosporum terminalioides*) flowers. This species is listed as a plant of conservation importance in the *Hawaii Plant Conservation Strategy* (2014) and qualifies as a DoD SAR. An estimated 24 wild plants remain worldwide, 10 of which are located at PTA. Source: CEMML staff

Under a cooperative agreement with CEMML/CSU, the Army uses ecosystem and species-specific approaches to manage ESA compliance and threats to SAR. ESA compliance is the primary natural resources management driver, and continued military training at PTA is contingent on meeting ESA commitments. Rare and declining ESA-listed species require action plans developed by installation staff or contractors/cooperators to mitigate impacts from further decline of local populations. Action plans for species may include mitigation activities that prevent or limit military training activities in areas critical to these species. One strategy the Army uses to minimize these possible mission impacts is to identify SAR and to collaborate with stakeholders to avoid additional ESA listings. The complex ecosystem at PTA includes very sensitive SAR, and the loss of a single species could lead to a chain reaction impacting numerous species across the island. Conserving SAR is critical to overall installation resilience since these species provide economic benefits through ecosystem services and sustain healthy natural environments for continued mission capabilities.

In 2019, CEMML conducted the first systematic analysis to identify all SAR at PTA. Specifically, CEMML gathered information through literature reviews, state and federal data, NatureServe data, and installation data to identify species meeting DoD's SAR criteria. These data included scientific and common name, ESA status, state status, NatureServe conservation status rank, International Union for Conservation of Nature status, and specific observation, occurrence, and distribution data on PTA. The baseline data helped to determine which SAR have a higher priority for management and

AFPMB'S ONE HEALTH FOCUS

By Douglas A. Burkett, Ph.D., DoD AFPMB

The AFPMB was established following World War II, largely due to a 260 percent malaria incidence rate among troops stationed in the Pacific. The need to develop and improve pest and vector-borne disease control equipment and management techniques quickly became clear. These initial efforts were so successful in improving operational force health that they continue today through the AFPMB.

The AFPMB mission has since evolved to focus on DoD pest management policy development and guidance to implement Integrated Pest Management (IPM) techniques across DoD to prevent or control pests and disease vectors that may impact military readiness. IPM is a decision-based process that incorporates biological, cultural, physical, and chemical tools to manage and reduce risks from pests. These techniques have proven successful because they consider not only the pests themselves, but also their hosts and the health of the environment that they impact. Evaluating these pieces allows for effective management controls while minimizing harmful impacts to other species. In recent years, the AFPMB has taken a “One Health” approach as we think about pest management programs. The One Health approach is a collaborative, multidisciplinary approach that integrates a variety of functional areas including pest management, natural resources, veterinary services, and environmental and public health.

The goal is for personnel associated with these functional areas to coordinate efforts. The natural interconnections between people, animals, wildlife, plants, and their shared environment enable us to execute large-scale efforts, create efficiencies, and better manage pest issues to meet goals. Pests have the ability to impact human health as well as damage structures, material, or property. Using this multi-functional approach improves an installation’s resilience by considering all vulnerabilities to pests. Recent and continuing outbreaks of COVID-19, Lyme and other tick-borne diseases, eastern equine encephalitis, West Nile virus, and other diseases remind us that human, animal, and environmental health are intimately connected. Further, the continued introduction of invasive species that serve as hosts, vectors, and agricultural pests complicates ecosystem interactions and will continue to have significant human health and DoD land stewardship implications.

This One Health approach has been at the forefront of recent AFPMB meetings and efforts. The most recent AFPMB meetings have included One Health related panels and presentations ranging from general to specific pest management issues. For example, we have discussed the impacts of a changing climate on pest distributions, biosecurity, invasive species, including those that provide refuge for ticks, and the resulting overall surveillance and pest management challenges. This One Health focus to facilitate and improve communication and coordination continued during the 211th meeting held in September and will continue to be at the forefront during future meetings. Although COVID-19 related events required a change to the agenda, senior Military Service pest management and natural resources leadership at a future AFPMB meeting will serve on panels to brainstorm how installations can improve the integration and communication between pest management and natural resources programs. These intertwined, yet often-independent, programs share



CEMML staff at PTA surveyed approximately 120 km² over a five-year period, recording over 13,000 locations of federally listed threatened and endangered plant species and 227 locations of plants considered to be SAR. Source: CEMML staff

monitoring. Additionally, some SAR may require more active management practices than others. Identifying these specific needs on installations can help maintain the overall biodiversity and health of the ecosystem.

The analysis identified 26 plant SAR and 24 animal SAR observed on PTA. The 50 total SAR are nearly four times the previous 13 SAR on PTA from a 2015 NatureServe study funded by the DoD Legacy Program. This discrepancy is likely a combination of incomplete data for the 2015 analysis; changes in species occurrences, federal status, taxonomy, and conservation status ranks; and varying levels of access to installation data. Keeping data up to date is a critical component to species management on any installation. These results will guide management actions for SAR, as well as support Recovery and Sustainment Partnership Initiative efforts between DoD and the Department of the Interior.

Maintaining native species populations on installations is a critical component of installation resilience as native species decrease the ability of invasive species to spread and establish populations. Invasive species can quickly degrade the local ecosystem leaving the land more susceptible to drought or wildland fires. Additionally, conserving native species enhances the overall ecosystem’s biodiversity, which is an important measure of an ecosystem’s resilience.

Although many sensitive species are expected to face additional challenges due to a changing climate, recent successes have included the downlisting of the Hawaiian goose (nene) from endangered to threatened, and the delisting of the Hawaiian hawk. In some instances, rare species at PTA are managed as SAR and co-occur with listed species. Current SAR management, consistent with the INRMP, assesses species’ status and implements appropriate landscape-scale conservation actions, including fencing, removing introduced large hoofed mammals (known as ungulates), controlling non-native predators, and managing fuels. These actions help prevent SAR losses due to direct threats such as fire or herbivory by introduced ungulates. They also increase resilience by reducing stressors from predators, invasive species, and other resource competition. Protecting species and their habitats will provide many ecosystem benefits to the installation for years to come.

responsibilities for military lands where Military Service members, DoD civilians, and their families live, work, and train. It is imperative that installations coordinate integrated pest and natural resources management plans to ensure economy and efficiency of efforts, which will make installations more resilient to pest distributions, biosecurity, and invasive species.

As many regions experience changes in climate and precipitation, environments become increasingly vulnerable to pest infestations. Being able to effectively understand which pests pose the greatest threats to military installations and how to effectively control them is increasingly important. Working with natural resources managers helps the AFPMB understand how management practices affect pests and the environments where they thrive. Understanding these interactions will improve management strategies and mitigate pest related risks. Considering alternative management strategies can also reduce the need to use control measures such as pesticides which can have harmful impacts on other native species in the area. These efforts improve installation resilience by reducing harmful impacts from pests and preventing additional stressors on native species and their habitat. Improved integration and communication between pest management, natural resources, veterinary, and public health communities will continue to dominate AFPMB discussions for the foreseeable future.

In other AFPMB news, and for those who may have missed it, please note our revised [DoD Instruction 4150.07](#), [DoD Pest Management Program](#), and our revamped [AFPMB website](#). Like us on [Facebook](#), where pest alerts and pest management items of interest are published daily.

OPPORTUNITIES TO PROMOTE CONSERVATION THROUGH MILITARY READINESS

By Timothy Male and Ya-Wei Le, Environmental Policy Innovation Center (EPIC)

DoD's roughly 25 million acres of land represent twice the area of all state parks in the United States. These lands support a density of threatened and endangered species that is four times higher than any other federal land managing agency. DoD programs, such as DoD's NR Program, oversee the management and conservation of nearly 500 ESA protected plant and animal species and over 550 additional species at-risk of requiring federal protection. Furthermore, the REPI Program has permanently protected more than 688,000 acres to preserve the military mission. Many of these acres have conservation value. Despite the current and future importance of military lands to both conservation and DoD's mission, relatively few conservationists are aware of the importance of DoD lands and natural resources programs, and even fewer conservation strategies include any significant focus on DoD. The lack of capacity in conservation groups focused on working with DoD is a major impediment to both the military and conservation groups to achieve their missions.

Without DoD's involvement, no strategy for conserving biodiversity, protecting ecological integrity, and maintaining resilience in the United States is truly complete. DoD lands provide some of the most extensive, connected, and diverse habitat for sustaining biodiversity. In fact, many DoD lands are relatively undisturbed, which provides realistic training situations for troops and ensures a safe, secure buffer around installations.

With a strong connection between the military mission and conservation, DoD is a crucial ally in offering unique resources to support conservation resilience efforts.

EPIC wants to facilitate better partnering between DoD and the conservation community, which will increase conservation and ecosystem resilience. To encourage this partnership, EPIC developed a report for the Military Services, [The Conservation of Defense](#), that outlines recommendations for how DoD can receive a better mission benefit from their conservation work while increasing conservation wins. The report provides an overview of challenges and opportunities for promoting conservation in conjunction with the military mission. Report recommendations benefit the military mission by supporting continued use of critical lands for training and readiness and protecting adjacent lands from encroachment, while providing environmental benefits resulting from DoD's land management policies and guidelines. One example is expanding the use of prescribed burning and forest fire risk management at DoD installations along with engaging in effective partnerships to improve fire risk management (i.e., lower fire risks to the military mission) and build more resilient landscapes. Another recommendation to promote installation resilience and conservation is to initiate more partnerships with local and regional conservation groups focusing on how a changing climate and natural resource issues might affect installation operations over the next 10 to 20 years. As potential partners learn about the role they can play, they can help the military increase installation resilience and conservation while addressing climate impacts and fulfilling their nonprofit mission.

The report recommends that nonprofits increase the staffing dedicated to engaging with DoD to address military and natural resource issues. The few groups that have done so have helped achieve important conservation victories for both DoD and the partners. For example, The Nature Conservancy partnered with DoD to support amendments to the Sikes Act that make it possible for DoD to enter into and support cooperative agreements to manage natural resources "outside the fence line" of installations, allowing for greater conservation, more



Naval Mobile Construction Battalion (NMCB) 133 Seabees work together to plant trees to support Restore America's Estuaries Week at Henderson Point in Pass Christian, Mississippi. Twelve NMCB 133 Seabees volunteered for the two day event where almost 600 trees were planted over seven acres. Source: Cliff Williams

resilience, and the preservation of the military mission. The National Wildlife Federation's collaboration with the military to produce a detailed guide to build climate risk analysis and resilience planning into INRMPs will aid resilience efforts on many of America's military installations. Other organizations, such as the U.S. Endowment for Forests and Communities, have helped DoD protect installations from encroachment while expanding forest protection by matching or leveraging funds to REPI Program resources. Future partnership efforts should focus on addressing funding, landscape-scale conservation and planning, endangered and at-risk species management, and resilience to changing climatic conditions.

Encouraging partnerships between conservation groups and DoD will ensure more environmental and conservation benefits on and off military lands. A primary focus of these partnerships should be building resilience to environmental changes due to the changing climate. DoD has already begun to focus on mitigating these threats (e.g., flooding, wind, drought, wildfire, and erosion) to decrease impacts to the military mission and increase installation resilience. Conservationists can focus on the mutual goal of creating more resilient lands by partnering with DoD on environmental and conservation initiatives.

For more information on all the report recommendations, see EPIC's [The Conservation of Defense](#) report published in early 2020.

SECRETARY OF DEFENSE ENVIRONMENTAL AWARDS

DoD established the Secretary of Defense (SecDef) Environmental Awards to celebrate Military Service members and civilians for their exceptional commitment to protecting human health and the environment while advancing the military mission. Since 1962, the SecDef has honored installations, teams, and individuals each year for outstanding, innovative, and cost-effective environmental management strategies that successfully support mission readiness. DoD announced the winners of the 2020 SecDef Environmental Awards on Earth Day, April 22. This year's awards cycle encompasses achievements from October 1, 2017, through September 30, 2019.

During that period, the Military Services and Defense Agencies (DoD Components) submitted nomination packages highlighting a range of achievements. Some noteworthy accomplishments include:

- **Army:** Fort Custer Training Center, Michigan Army National Guard, was the first installation to implement its own customized climate adaptation plan into its INRMP. Staff partnered with researchers to determine the best fire application regimes to manage invasive species, promote native species growth, and support wildlife. These research efforts are critical to filling the data gap between prescribed fire management and long- and short-term species impacts. Creating an installation specific climate adaptation plan has allowed natural resource managers to make important decisions about resilience efforts such as wildfire management to support the long-term health of the installation's ecosystem.
- **Marine Corps:** MCAS Miramar, California, personnel used a trailer-mounted system to remove per- and polyfluoroalkyl substances (PFAS) from 320,000 gallons of wastewater. Using this innovative approach, the Marine Corps remediated PFAS concentrations to levels below the U.S. Environmental Protection Agency's health advisory level and the regional screening levels, easing the burden on local water treatment facilities and ensuring the long-term safety of installation personnel and civilian neighbors. Keeping groundwater free of contaminants also keeps the species on the installation and surrounding area healthy, supporting a resilient environment.
- **Navy:** NAVBASE Kitsap, Washington, personnel improved the quality of the water surrounding the installation by implementing several innovative conservation projects. Staff removed beaver dam debris from a culvert along NAVBASE Kitsap's railroad, providing access to over five acres of upstream habitat for endangered species. Staff at NAVBASE Kitsap also initiated a pilot program using oyster shells to lower elevated zinc levels in stormwater runoff; preliminary analytical results demonstrate a 75 percent reduction in zinc concentration. An increased amount of zinc discharging into local waterways could have created more turbid waters, and an increase in turbidity can change other stream characteristics and allow for algae growth. Maintaining healthy waterways is important for ecosystem resilience during storm events and to avoid flooding.
- **Air Force:** Hurlburt Field, Florida, personnel swiftly addressed the rapid expansion of invasive apple snails, a species that strips vegetation, degrades natural areas impacting threatened and endangered species, and passes zoonotic diseases to humans. They captured 53 adult snails, removed 3,510 egg masses, and secured help from 10 AmeriCorps interns to increase trapping in 2020. Partners such as USFWS, Florida Fish and Wildlife Conservation Commission, University of Alabama, and Rollins College worked together and increased their knowledge to improve capture protocols and techniques across the region and on other public lands in the United States. Invasive species can have harmful impacts on ecosystems. Managing invasive species is important in maintaining local species populations, protecting biodiversity, and ensuring the overall resilience of the ecosystem.
- **Defense Logistics Agency:** Installation Management, Defense Supply Center Columbus, Ohio, personnel planted a three-acre native prairie in December 2017. The prairie consists of all native Ohio grasses, perennials and annuals. Staff formulated the mix for pollinators, and it contains blooms for spring, summer, and fall. Simultaneously, the team worked with Morale, Welfare, and Recreation to plant the same seed mix at the golf course in rough areas. The combined effort has resulted in substantial pollinator habitat to help sustain these species populations on the installation. Pollinators are responsible for pollinating 90 percent of wild plants. Native plants are essential resources that offer clean air and water and support other critical wildlife. Maintaining healthy plant populations is a fundamental strategy in increasing installation resilience.

For more information on the SecDef Environmental Awards program, including information about the 2020 winners and honorable mentions, visit the awards program website at <https://denix.osd.mil/awards/>.

DOD PROJECT HIGHLIGHTS

In keeping with our issue theme of highlighting resilient military installations, the following project summaries detail recent resilience efforts on DoD lands. Find more projects on the Natural Resources page of the DoD Environment, Safety and Occupational Health Network and Information Exchange (DENIX) website or on the Strategic Environmental Research and Development Program (SERDP)/ Environmental Security Technology Certification Program (ESTCP) website.

Legacy Project NR-17-841: Evaluating Costs and Benefits of the Department of Defense Legacy Resource Management Program

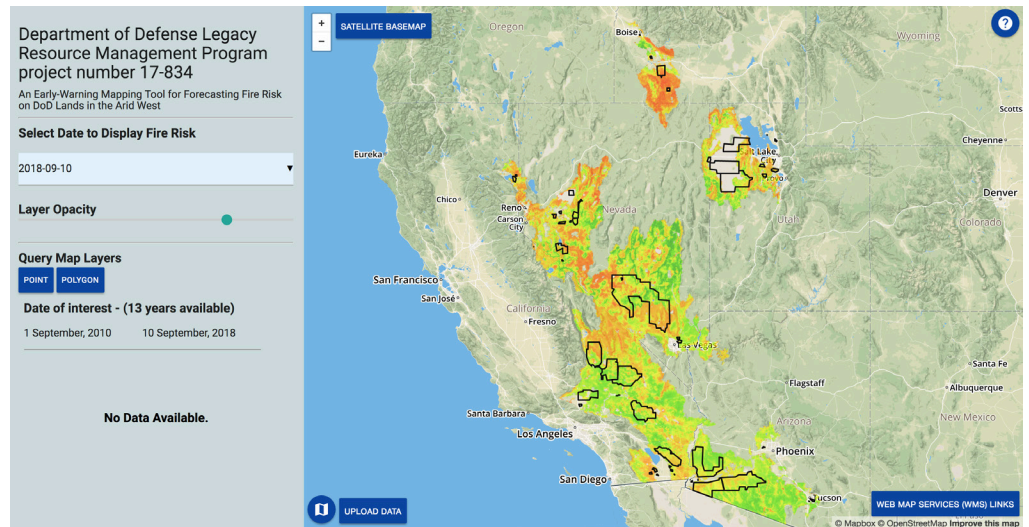
In 1990, Congress passed legislation establishing the Legacy Resource Management Program to provide financial assistance to DoD for installation-specific efforts to preserve our natural and cultural heritage while supporting military readiness. This analysis looked at various sources of data to determine the net benefit of the Legacy Program. While the project team concluded that the data currently available is insufficient to conduct a cost-benefit analysis for effectively quantifying benefits in a uniform way, this study did find sufficient information to link Legacy Program activities to beneficial military readiness outcomes, such as training days saved and costs avoided. Researchers quantified these beneficial outcomes to frame an approach for conducting a cost-effectiveness analysis. The recommendation of this study is to use DoD personnel and a structured decision support process to create a practical assessment approach to evaluate Legacy Program project outcomes. Implementing strategic uniform methods of evaluation is a key component to quantifying the benefits of the Legacy Program on natural resources and the military mission.

Legacy Project NR-17-834: An Early-Warning Mapping Tool for Forecasting Fire Risk on DoD Lands in the Arid West

Wildfire risk is an increasingly important topic for military installations, particularly those located in the arid West. The “Wildfire Risk Explorer” is a new mapping tool that evaluates fire risk at military installations in the western United States. This tool uses climate, topography, vegetation, and vegetation productivity data to predict fuel and fire behaviors and how they contribute to an area’s fire risk. This data supports predictions about variables such as the amount of organic matter present and how it influences fire behavior to accurately represent fire risk. This tool can help installations better prepare for and adapt to future wildfire events to become more resilient.

SERDP RC-2511: Flow-Population Models for Tracking Non-Stationary Changes in Riparian and Aquatic Ecosystems

Changes in temperature and precipitation patterns on military land in the western United States will impact the timing, frequency, and magnitude of flood and drought events. These changes in climate also affect aquatic ecosystems, including stream-dependent birds, reptiles, and mammals. Impacted species will likely include many federally threatened, endangered, and at-risk species. While climate models have become increasingly more sophisticated and accurate, they cannot predict the specific impacts that changes in temperature and precipitation will have on aquatic and riparian species. This project aimed to fill that knowledge gap by forecasting potential impacts on aquatic and riparian species. Preliminary results reveal important tradeoffs between optimal stream flow and disturbed flow models for all species. This project will help address data gaps between changing hydrologic patterns and how populations of aquatic and stream-dependent species respond to them. Having the ability to predict these population changes will help frame natural resources management decisions to avoid or mitigate negative impacts to local hydrology or aquatic species, allowing for more resilient waterways.



Early-warning interactive mapping tool for forecasting fire risk on DoD lands in the arid west. Source: DoD Legacy Resource Management Program

SERDP RC-2707: Understanding Species Persistence in Complex Landscapes with a Long-Term Metapopulation Study of Rare Flora

Long-term datasets can provide important information for ecological sciences because they consider varying biotic (i.e., living) and abiotic (i.e., non-living) conditions. The objective of this project was to investigate factors contributing to population persistence of long-lived plant species using long-term monitoring. This project studied factors including fire frequency, canopy cover, metapopulation structure, and functional traits of 1,396 populations for 41 plant species at Fort Bragg over 23 years. The preliminary results of this study have shown that in all species, populations benefit from frequent fires, lower canopy cover, high connectivity, large areas of occupancy, or locations in upland habitats. These findings provide important information to help determine the most effective species-specific management strategies to increase population persistence for threatened, endangered, and at-risk species.

SERDP RC-2432: The Impact of Non-Native Predators on Pollinators and Native Plant Reproduction in a Hawaiian Dryland Ecosystem

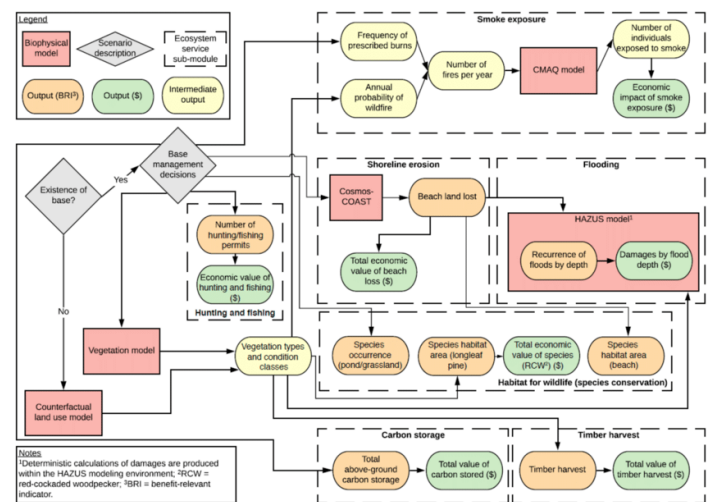
Invasive species can target pollinators, harming native plant reproduction and genetic diversity. These impacts can be particularly detrimental in sensitive and unique biologically diverse regions such as oceanic islands. Non-native invasive predators (NIPs) consume animal pollinators, reducing pollinator populations and negatively impacting native plant species. This project used field observation, experimental manipulation, and laboratory analysis to study the interaction between eight native plants, insect pollinators, and NIPs. Preliminary results from this study show that pollinator management and conservation are important for managing threatened and endangered plant species, and that NIPs negatively impact pollinator-plant interactions. Control treatments for NIPs, such as ants and rats, will likely help improve these interactions but will require continuous efforts. Learning more about the interaction between NIPs, pollinators and sensitive plant species will provide researchers with more information about the ways NIPs affect pollinators and the plant species that depend on them. Understanding this interaction is important to maintaining native plant populations and the long-term sustainability of island ecosystems.



O'opu nākea (Awaous guamensis). An example of an at-risk native goby fish in Hawai'i threatened by aquatic invasive species. Source: DoD SERDP

SERDP RC18-1604: Assessing Ecosystem Service Benefits from Military Installations

Across the United States, many military lands remain undeveloped and provide important ecosystem functions to the surrounding areas such as flood protection, plant and wildlife habitat, recreational areas, and carbon sequestration. Through this project, researchers developed methods to conceptualize and quantify the ecosystem services that military installations provide. Specifically, using an integrated modeling platform, MoTIVES, researchers quantified the ecosystem services provided at Eglin AFB in Florida. Eglin AFB contains the largest mature longleaf pine forest in the world and provides habitat for 24 species listed as threatened or endangered under the ESA. Additionally, Eglin AFB contains coastal streams and bays that support at-risk aquatic species, and the eastern portion of the base is a Gulf of Mexico barrier island, providing protection from storm surges and coastal flooding. The project team evaluated three scenarios using the MoTIVES model including current management, no management, and no-base. Using these three scenarios, the model analyzed conditions based on current base management practices, military operations with no management, and no management or military operations. The simulation showed that natural resources management at Eglin AFB supports flood protection and habitat for the red-cockaded woodpecker. These ecosystem services provide an estimated value of around \$110 million per year.



Schematic diagram of the major components of the MoTIVES integrated model for Eglin AFB. Of the ecosystem service sub-models shown here, the Eglin case study included carbon storage, wildlife habitat, flooding, hunting and fishing, but not shoreline erosion or smoke exposure. Source: DoD SERDP

Under current management practices, the largest amount of suitable habitat area for threatened and endangered species was present, in the longleaf pine forest and coastal areas. This area was significantly reduced for all species under the no base scenario. This model can be an important tool in quantifying the importance of natural resources management on military installations. In this example, current management practices are more beneficial to ecosystem services than no management activities if the base was no longer present.

UPCOMING EVENTS, CONFERENCES, WORKSHOPS, AND TRAINING

National Wildlife Refuge (NWR) Week

October 11-17, Nationwide

Wildlife refuges provide excellent opportunities to hunt, fish, and hike. These special places not only feature native plants and wildlife habitat, but also provide important ecosystem functions by filtering pollution from the air and water. Come out to visit one of the nation's 567 refuges to celebrate NWR Week. Before you visit, be sure to check local policies regarding COVID-19.

13th Biennial Longleaf Conference – Longleaf: The Resilient Landscape

October 20-23, Virtual

The Biennial Longleaf Conference is a regional event focused on the restoration and conservation of the longleaf ecosystem that once dominated the landscape in the southeastern United States. The conference provides the opportunity for people from all over the southeast to share, learn about, and celebrate longleaf. This conference is open to individuals, private landowners, land managers, wildlife biologists, conservation groups, consultants, university researchers, forestry professionals, and agency and outreach personnel who share an interest in restoring the longleaf ecosystem. The Longleaf Alliance is hosting the biennial longleaf conference virtually due to COVID-19. The virtual format will offer the same informative and timely content from presenters with opportunities to connect with members and sponsors from across the region in new ways.

SERDP and ESTCP Symposium

November 30-December 4, Virtual

The SERDP and ESTCP Symposium is the nation's largest conference focusing on DoD's priority environmental and installation energy issues. The Symposium brings together environmental and energy researchers and technology developers with the defense end-user and regulatory communities to showcase cutting edge environmental technologies and ideas. The 2020 Symposium will offer 16 technical sessions, a number of short courses, more than 450 technical poster presentations, exhibitors from funding and partnering organizations, and a variety of networking opportunities for the more than 1,000 attendees.

Western Association of Fish and Wildlife Agencies (WAFWA) Mid-Winter Meeting

January 5-8, Virtual

The Western Association of Fish and Wildlife Agencies represents 24 states and Canadian provinces, an area covering nearly 3.7 million square miles of some of North America's most wild and scenic country. WAFWA supports sound resource management and partnership building at all levels to conserve wildlife for the use and benefit of all citizens, now and in the future. This event will feature council and working group meetings, briefings, and networking opportunities.

North American Wildlife and Natural Resources Conference

March 8-12, Virtual

The 86th North American Wildlife and Natural Resources Conference will bring together natural resources professionals from all sectors to exchange knowledge and best practices on issues such as endangered species, migratory birds, and landscape management through workshops and meetings. The event serves as the annual forum to set conservation policy in North America and includes conference sessions, workshops, and more than 150 separate meetings and functions.

National Military Fish and Wildlife Association (NMFWA) Annual Meeting and Training Workshop

March 8-12, Virtual

Held in conjunction with the North American Wildlife and Natural Resources Conference (above), the NMFWA annual meeting and training workshop is the primary event where installation natural resources managers meet to discuss key concerns and opportunities, recent policy and legislative changes, ongoing activities and recent accomplishments, and emerging issues and potential new challenges.

LINKS OF INTEREST

DoD Natural Resources Program (NR Program)

DoD's NR Program provides policy, guidance, and oversight to manage natural resources on approximately 25 million acres of military land, air, and water resources. Visit the NR Program website for more information on DoD's natural resources initiatives, policy updates, presentations, and links to other conservation and natural resources sites.

DoD Environment, Safety and Occupational Health Network and Information Exchange (DENIX)

The DENIX Natural Resources website is another resource that provides access to natural resources information. Specifically, the website includes DoD Legacy Resource Management Program fact sheets and reports, as well as other natural resources materials.

Armed Forces Pest Management Board (AFPMB)

AFPMB recommends policy, provides guidance, and coordinates the exchange of information on pest management throughout DoD. Its mission is to ensure that environmentally sound and effective programs are in place to prevent pests and disease vectors from adversely affecting natural resources and DoD operations.

Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP)

SERDP and ESTCP are independent DoD research programs that use the latest science and technology to develop innovative solutions to DoD's environmental challenges. They promote partnerships and collaboration among academia, industry, the Military Services, and other federal agencies that support military readiness and mission capabilities, quality of life, compliance with legislation and policy, and natural and cultural resources management.

Readiness and Environmental Protection Integration (REPI)

Under REPI, DoD partners with conservation organizations, and state and local governments to preserve land around military installations to combat encroachment. REPI promotes innovative land conservation, which preserves the military's ability to train and test on its lands now and into the future.

Cooperative Ecosystem Studies Units (CESU) Network

DoD participates in the CESU Network, which is a national consortium of federal agencies, tribes, academia, state and local governments, and non-governmental organizations working together to provide research, technical assistance, and training to federal agencies and their partners. The CESU Network also provides managers with the adaptive management approaches necessary to preserve installation natural and cultural resources.

DoD Partners in Flight (PIF)

DoD PIF consists of natural resources personnel from military installations across the United States and works collaboratively with partners throughout the Americas to conserve migratory and resident birds and their habitats. In addition, DoD PIF supports and enhances the military mission through proactive, habitat-based management strategies that help protect birds on DoD lands and maintain healthy landscapes and training lands. Visit the DoD PIF website for fact sheets, reports, and other materials with information about DoD's migratory bird conservation efforts.

DoD Partners in Amphibian and Reptile Conservation (PARC)

DoD PARC is a partnership dedicated to the conservation and management of herpetofauna (reptiles and amphibians) and their habitats on military lands. DoD PARC membership includes natural resource specialists and wildlife biologists from the Military Services, and individuals from state and federal agencies, museums, universities, and environmental consultants. Visit the DoD PARC website for information about herpetofauna management projects on DoD lands.

DoD Pollinator Initiatives

Visit this website for an overview of pollinators and why they are important to DoD. The website also contains information on how people can help protect pollinators and their habitat, including fact sheets, technical reports, and how-to guides.

DoD Invasive Species Outreach Toolkit

This toolkit has materials to help DoD natural resources managers communicate with agencies, organizations, and the public about invasive species issues on DoD lands. Specifically, the tool kit includes modifiable outreach materials, such as posters, brochures, reference cards, and a PowerPoint presentation.

DoD Biodiversity Handbook

The DoD Biodiversity Handbook contains a thorough introduction to biodiversity and how it is essential to support the military mission. It also details the scientific, legal, policy, and natural resources management contexts for biodiversity conservation on DoD lands, and includes 17 case studies with practical advice from DoD natural resources managers.

DoD PARC Photo Library, DoD PIF Photo Library, and DoD Natural Resources Photo Library

Visit these three websites to share pictures, news, information, and ideas with the DoD Natural Resources, DoD PARC, and DoD PIF communities. Please review the [photo policy](#) and [photo submission instructions](#) to contribute your images. In addition, account users can download photographs for reports, PowerPoint presentations, and educational materials such as brochures and posters.

DoD Chesapeake Bay Program (CBP)

DoD was one of the first federal departments to be formally involved in the Chesapeake Bay Watershed restoration effort. Military installations in Maryland, Pennsylvania, Virginia, New York, West Virginia, and the District of Columbia play an important role in defending and preserving the Bay. In Fiscal Year 2019, installations funded \$65 million in projects that benefit the Bay. These efforts advance the goals and outcomes of the Bay and further the ability for DoD to test, train, and operate in the watershed.





DOD NATURAL RESOURCES PROGRAM

Enabling the Mission, Defending the Resources

www.denix.osd.mil/nr

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